New Technique Peers Into Bones and Teeth

Conventional X-ray of rheumatoid arthritic swelling in a hand. ▲

BMDO Technology Background

A new and powerful X-ray technique developed at Lawrence Livermore National Laboratory (LLNL; Livermore, CA) and Germany's University of Dortmund allows researchers a three-dimensional look at the interior of materials such as industrial ceramics, metal matrices, bones, and teeth. BMDO-sponsored research at LLNL and Sandia National Laboratories led to the development of this technique, called X-ray tomographic microscopy (XTM). XTM is similar to CAT scanning and has a resolution of about 1 micron, which is roughly 500 to 1,000 times sharper than CAT.

How It Works

In the XTM apparatus, X-ray photons pass through a sample positioned on a rotating stage. They are then converted to visible light on a scintillator screen and imaged with a two-dimensional CCD detector. The CCD allows multiple, contiguous tomographic cross sections to be collected at the same time, so the volume can be viewed in cross section by slicing through the structure in any planar direction. Such planes can be combined to produce a three-dimensional rendering of the structure, emphasizing material of either higher or lower density. A strain microscope attachment developed by Sandia allows examination of structures under load.

XTM can use either synchrotron-produced or conventional X-ray sources but a synchrotron radiation source results in the highest resolution. XTM can obtain 2,000 image "slices" in less than an hour.

Potential Use to Medicine

XTM is currently being used to study the microstructure of bones and teeth. With a grant from the National Institutes of Health (NIH) and the National Institute of Dental Research, researchers are using XTM to map mineral distribution in teeth. This research can shed light on how dental caries (cavities) form and may lead to improved filling composites.

XTM can also image the lacy, inner matrix of bone and reveal how bone loss and bone formation occur. An understanding of these processes can help researchers devise new remedies for osteo-porosis and arthritic bone degradation, and perhaps help to explain how estrogen retards bone loss.

Researchers are also looking at the utility of XTM in catheterization procedures such as balloon angioplasty. The main obstacle to this use is the large size of synchrotrons needed as an X-ray source.

Pharmaceutical firms, such as Eli-Lilly, Procter and Gamble, and Merck, are interested in using XTM in their drug research.

Product Status and Availability

In vivo studies in bone loss are now being conducted with XTM at the University of California, under a 3-year NIH grant. Drug companies such as Roche Bioscience are actively working with LLNL, using XTM to determine how steroidal drugs break down bone. Other pharmaceutical firms, such as Eli-Lilly, Procter and Gamble, and Merck, are also interested in using XTM in their drug research. Dr. John Kinney, principal investigator at LLNL, is interested in collaborative research proposals from other companies, as well.